HUMAN-ELEPHANT CONFLICT IN A COLONISED SITE OF DISPERSED ELEPHANTS: KOUNDINYA WILDLIFE SANCTUARY (ANDHRA PRADESH, INDIA)

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This paper discusses human-elephant conflict (HEC) in Koundinya Wildlife Sanctuary (KWS), one of the two sites in Andhra Pradesh colonized by elephants during the 1980s after dispersing from sites in Tamil Nadu and Karnataka states. The nature and extent of the past and present HEC, causes for the conflict, mitigation measures adopted, and their effectiveness are discussed based on a one year study (January-December 2005). The findings reveal that the primary reason for the decline in HEC is due to the decline in elephant numbers, especially adult bulls in the case of man slaughter, and that the crop damage mitigation measures adopted by the Forest Department have not been a success on the whole. As for tackling HEC, we suggest translocation of the animals to other elephant habitats as the existing small population (12 individuals) is theoretically speaking not viable to survive into the future and due to the problems facing the Sanctuary, unless the Forest Department is keen on conserving the species in KWS for which management measures are recommended.

Keywords: Asian Elephant, Koundinya Wildlife Sanctuary, crop damage, human-elephant conflict, conservation

INTRODUCTION

Historically, Andhra Pradesh was not known to have elephants since the past 200 years (Syam Prasad and Reddy 2002). However, during the early 1980s, a small herd of elephants moved into the Kuppam and Palamaner forests of Chittoor district in Andhra Pradesh from the Hosur and Dharmapuri forests of Tamil Nadu, *c.* 60 km to its southwest. An assessment of the animals and their habitat (Sivaganesan and Bhushan 1986) found the habitat to be sub-optimal and postulated that the elephants had moved into the area due to drought in their normal distributional range and would move back into their original home during the next (favourable) monsoon. However, this did not happen, and later, more elephants migrated into the area during 1986 reportedly from the Bannerghatta National Park, Karnataka, which adjoins the Hosur-Dharmapuri forests. Some of the elephants that moved into Kuppam-Palamaner forests later dispersed north into the Sri Venkateswara Wildlife Sanctuary-National Park (Andhra Pradesh) and southwards to the Javadi Hills (Tamil Nadu).

The presence of elephants initially welcomed by the locals due to religious sentiments and ignorance of the problem potential of elephants changed rapidly with incidences of crop damage and human deaths. Attempts to drive them back into the the Hosur-Dharmapuri forests were unsuccessful. With time, the Andhra Pradesh Forest Department accepted the presence of elephants in their state and declared an area of 357 sq. km in the Kuppam and Palamaner forest areas as the Koundinya Wildlife Sanctuary (KWS). However, this and subsequent management measures did not help in improving the situation, and over the years, a total of 45 humans deaths, 24 elephant deaths and nearly 4,000 crop and property damage claims were registered with the Forest Department. The Bombay Natural History Society (BNHS) undertook this study from January 2005 to December 2005 (Daniel *et al.* 2006) primarily to assess the current situation of elephants and the habitat in KWS, and in this paper, we analyse the past and present human-elephant conflict in KWS and examine the mitigation measures adopted by the Forest Department and their effectiveness.

STUDY AREA

Koundinya Wildlife Sanctuary (12°39'-13°10' N; 78°29'-78°52' E; 357 sq. km), Chittoor district, Andhra Pradesh, falls within the hill ranges of the Eastern Ghats, a broken and discontinuous line of mountain range in peninsular India. KWS (Fig. 1) is linear in shape, running about 70 km north to south and the breath varies from *c.* 1 to 15 km. It has a periphery of about 224 km with 53 fringe villages and 8 enclosure villages. The Sanctuary comes under two ranges: Palamaner in the north and Kuppam in the south. Palamaner Range is divided into four blocks: Tekumanda, Musalimadugu, Mordana and Nellipatla. The Kuppam Range has six blocks: Naikaneri, Peddanaikdurg, Charagallu, Peddur Extension, Peddur and Kangundi.

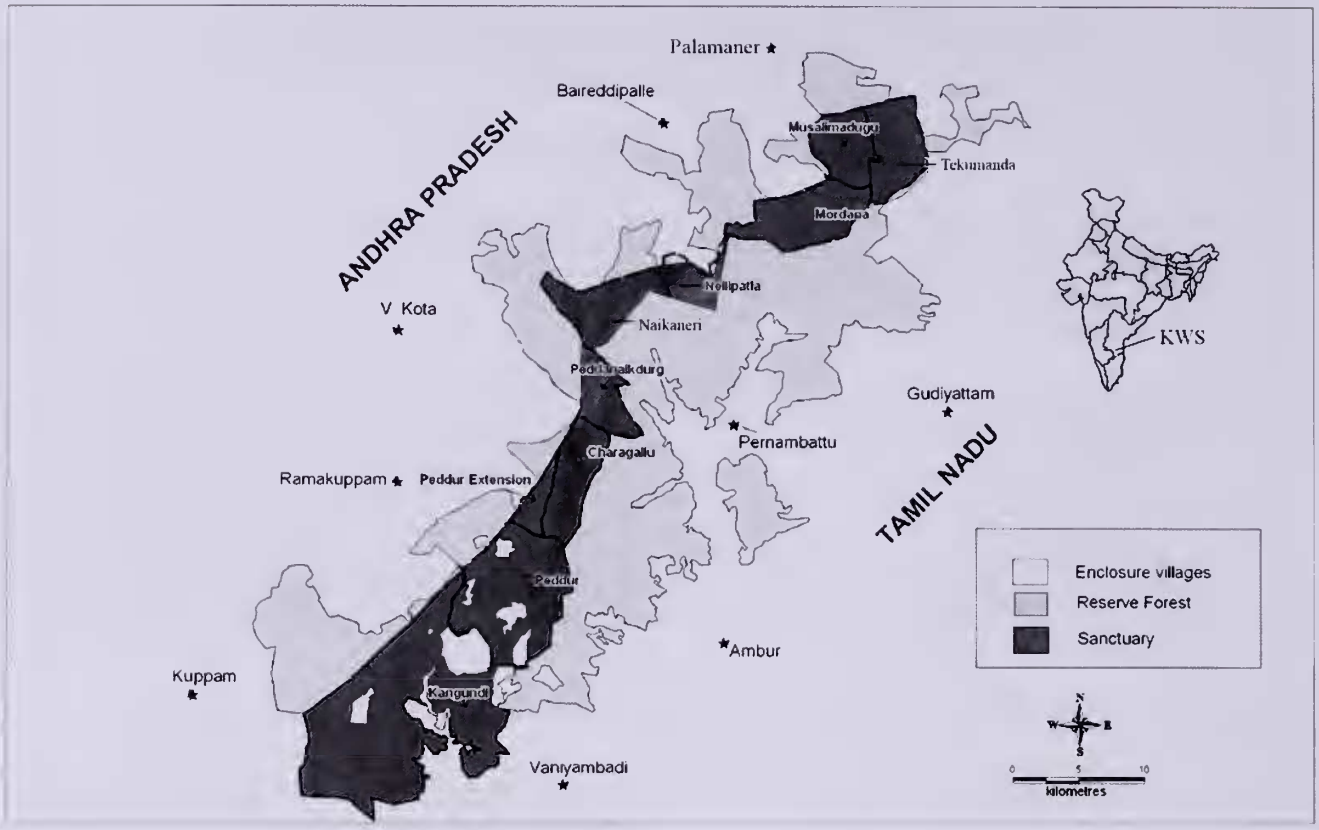

Fig. 1: Koundinya Wildlife Sanctuary: the study area

The water sources in the Sanctuary consists of the River Palar, its tributaries the Malattar (or Kaigal) and Koundinya, besides monsoonal streams. In general, water is available only at some places of the Palar and its tributaries during summer and water scarcity is severe during years of low rainfall. The other water sources in the Sanctuary comprises of natural or man-made ponds or lakes, most of which are largely situated at the outskirts of the fringe and enclosure villages.

Chittoor district receives rainfall from the South-West Monsoon (June-August) and North-East Monsoon (October-December), averaging about 380 mm and 410 mm respectively. However, the distribution of rainfall is uneven and the area is drought prone. The cold weather is from November to February with temperatures sometimes dropping to 10°C. Summer (March-May) is mild with maximum temperature of about 33°C (Anon. 2004).

The vegetation is predominantly of Southern Tropical Dry Mixed Deciduous (Champion and Seth 1968), comprising of trees such as *Hardwickia binata*, *Chloroxylon swietenia*, *Albizzia amara*, *Boswellia serrata*, *Anogeissus latifolia*, *Pterocarpus santalinus*, *Shorea* spp., *Diospyros* spp. and *Ficus* spp. The water courses are dominated by *Terminalia arjuna*, *Pongamia pinnata*, *Tamarindus indica*, *Mangifera indica*, and *Syzigium cumini*. However, the vegetation varies widely in different areas as a result of terrain, soil, impacts of grazing, fires, woodcutting, and history of exploitation. Due to the past history of exploitation for timber and fuel, most of the trees in the Sanctuary (except for minor forest produce species) have resulted from coppice growths or have got established in the last two to three decades, which explains their overall short stature. The exotic *Lantana camara* has invaded vast areas of the Sanctuary.

The major mammals reported from the Sanctuary are the Bonnet Macaque *Macaca radiata*, Hanuman Langur *Presbytis entellus*, Slender Loris *Loris tardigradus*, Leopard *Panthera pardus*, Striped Hyena *Hyaena hyaena*, Sloth Bear *Melursus ursinus*, Dhole *Cuon alpinus*, Jackal *Canis aureus*, Small Indian Civet *Viverricula indica*, Common Indian Mongoose *Herpestes edwardsi*, Indian Porcupine *Hystrix indica*, Indian Hare *Lepus nigricollis*, Indian Flying Fox *Pteropus giganteus*, Spotted Deer *Axis axis*, Four-horned Antelope *Tetracerus quadricornis*, Mouse Deer *Tragulus meminna* and Wild Boar *Sus scrofa*.

METHODS

Data on the past human-elephant conflict (HEC) in KWS was obtained from the Divisional Forest Department office at Chittoor and the two Forest Range offices at Kuppam and Palamaner. Apart from this, questionnaire surveys were

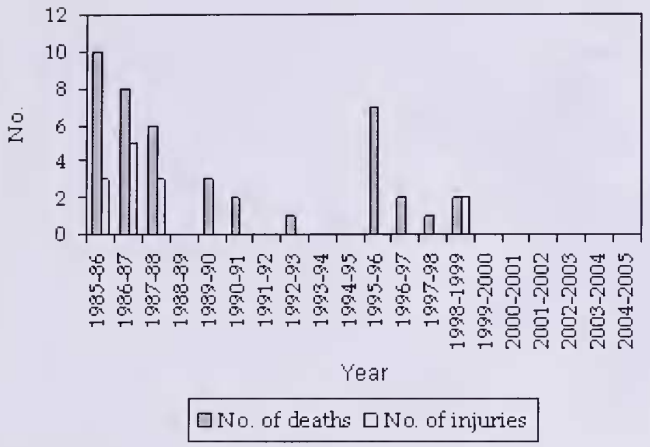

Fig. 2: Year-wise human death and injuries (1985-2005)

carried out in villages in and around the Sanctuary to have actual accounts of locals and information of unreported cases. A total of 45 fringe and enclosure villages in Andhra Pradesh and 18 bordering villages in Tamil Nadu were surveyed.

Information on the current HEC incidences was obtained through the above mentioned surveys and also from visits made to sites on reports received from villagers, Forest Department personnel and local newspapers. The data collected included the name of the village raided, crops/ property damaged, the extent of damage and the age-sex and group size of the raiding elephants. Measures adopted by the Forest Department (i.e., compensation, power fences, trenches, driving by elephant trackers) to prevent or mitigate human-elephant conflict and their effectiveness were assessed through actual observations and queries with affected people. Peoples' attitudes towards elephants were sought during the surveys and other field visits.

RESULTS

Past HEC

Human Deaths and Injuries: Being new to elephants and ignorant of their dangers and on how to deal with them, 45 people were killed and 13 injured in the KWS area from 1985 to 1999 (Fig. 2). The deaths and injuries resulted from people venturing to see elephants at village outskirts (a person even going to the extent of offering a coconut due to religious beliefs), while protecting crops against raiding elephants, when elephants passed through villages, and encounters on forest trails. With time, people recognized that elephants were dangerous and learnt to be wary and this resulted in a decline in deaths and injuries. However, encounters during crop raiding continued and this resulted in some deaths and injuries. With the capture of the bulls that were responsible for much of the conflict, no incidents of human deaths and injuries occurred after 1999. Though the identities of elephants responsible for deaths or injuries was not certain (as many occurred at night), enquiries with villagers revealed that bulls were generally responsible for many of the incidences. Most of the deaths and injuries that took place outside the forest areas (i.e., agricultural fields and villages) occurred in the late evenings or at night, while cases in forest areas occurred during the day and involved mostly herdsmen and woodcutters.

Elephant Deaths: Twenty-four deaths of elephants were reported between 1987 and 2003 in the Koundinya area. Reasons attributed for deaths include electrocution (54%), natural death (33%) and unknown causes (13%). Electrocution occurred primarily during crop raiding through contact with power lines laid by villagers to kill wildboar entering crop fields. A high number of deaths occurred between 1988 and 1993, and occurred mainly in the Kuppam Range, suggesting that even then (as is now) elephants ranged more in the southern part of the Sanctuary. Besides deaths given in Forest Department records, Sivaganesan and Bhushan (1986) obtained reports of a death of an elephant in the bordering Tamil Nadu area in the 1980s.

Crop and Property Damage: Forest Department records cite a total of 4,010 crop and property damage claims made from 1985 to 2004 and a total compensation amount of *c.* Rs. 2.57 million paid to the claimants. Our village surveys revealed that crop damage was earlier widespread all along the villages at the periphery of the reserve forests of Tamil Nadu that border the Sanctuary from Mordana in the north to Kothur (Nattarampalli) in the south-west (Fig. 3, see Fig.1 for more place names). Crop damage also occurred along the dispersal route between Krishnagiri and KWS. HEC has totally stopped in all areas of Tamil Nadu which border KWS since the last five years, except for the Sarangal area, which is located on the outskirts of the reserve forests that adjoin the Charagallu block, an area much frequented by elephants.

Present HEC

Human Deaths and Injuries: There were no human deaths or injuries during the study period, which is the case after 1999. The only report received of a near case of human-elephant encounter was of a herdsman, who reported having been chased off by a big bull when he came upon the herd in the Nellipatla block.

Elephant Deaths: Elephant deaths were not recorded during the study period.

Crop and Property Damage: Forty-four cases of crop damage from 17 villages were recorded during the study period (Figs 3, 4). The species raided were Ragi or Finger Millet (*Eleusine coracana*), Paddy (*Oryza sativa*), Maize

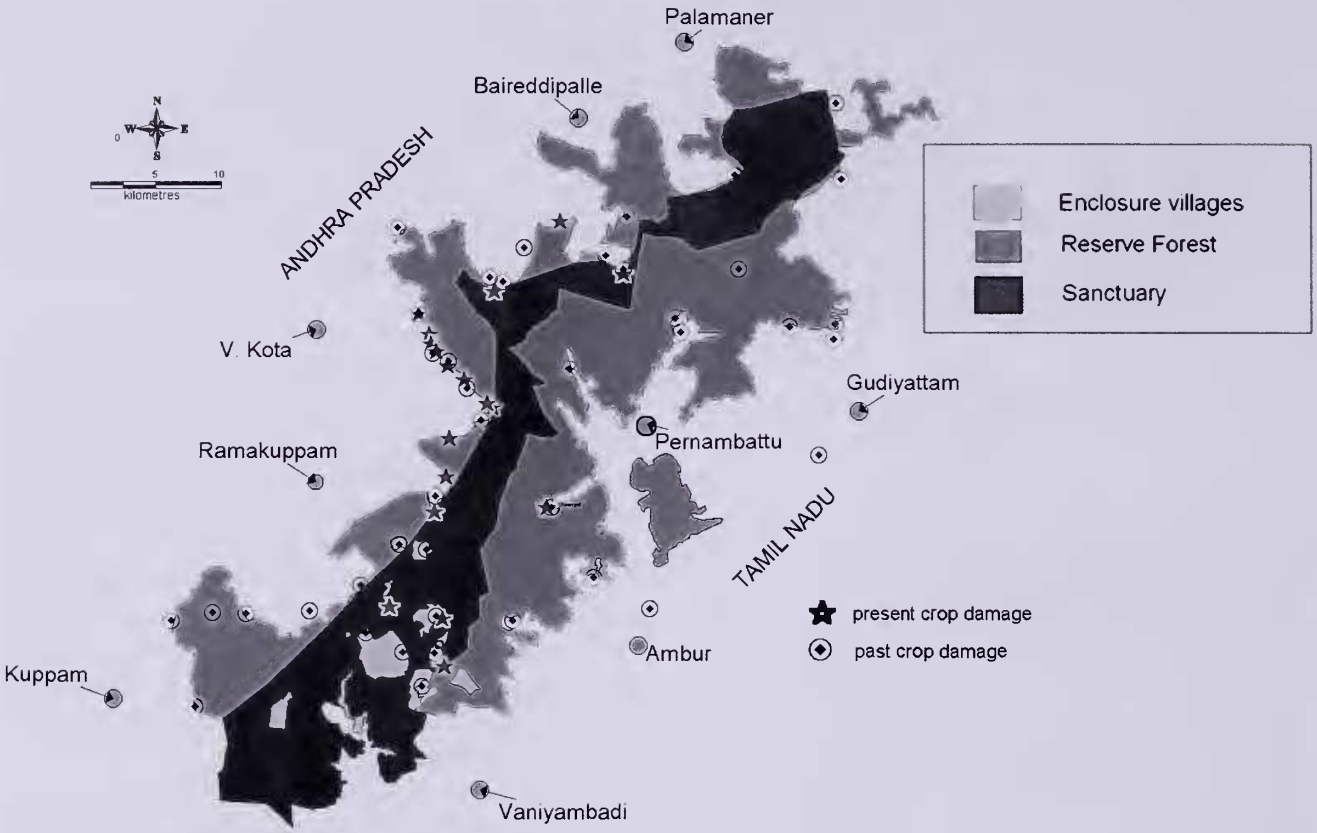

Fig. 3: Crop raiding pattern of elephants in the Koundinya Wildlife Sanctuary

(*Zea mays*), Sugarcane (*Saccharum officinarum*), Groundnut (*Arachis hypogea*), Banana (*Musa paradisiaca*), and vegetables comprising mainly of tomatoes and bean species (Table 1). Elephants damaged crops both by eating and trampling. Coconut (*Cocos nucifera*) and mango (*Mangifera indica*) were trees that were uprooted/damaged. In the case of coconut (5 trees), the tree was pushed down to feed on the foliage, thus killing the tree. The solitary bull (sometimes accompanied by the subadult bull from the herd) was responsible for 59% of the raids and the (single) herd for the rest. Damage to property recorded during the study period consisted of a crop owner's watch-hut (1 case) and irrigation pipes (2 cases).

Table 1: Crop species damaged by elephants and the extent and nature of damage

Crop	Area of field (ha)	Area damaged (ha)	Eaten/ Trampled
Ragi (*Eleusine coracana*)	16.74	4.1	E
Paddy (*Oryza sativa*)	10.87	3.03	E
Sugarcane (*Saccharum officinarum*)	7.72	0.58	E
Maize (*Zea mays*)	2.57	1.82	E
Bean species	1.96	1.1	T
Tomatoes (*Lycopersicum esculentum*)	1.76	1.5	T
Fodder grass species	0.55	0.18	E
Groundnut (*Arachis hypogea*)	0.40	0.07	T
Total	42.57	12.38	-

Note: Bananas *Musa paradisiaca* (3 fields), Coconut *Cocos nucifera* (5 trees) and Mango *Mangifera indica* (1 tree) were the other species that were damaged/killed.

Peoples Attitude to Elephants

The majority of the villagers (n=65) interviewed during the surveys said that they were averse to elephants in their areas due to the dangers posed and resulting restriction of their movements in forests. A small number (15) opinioned that they did not mind or even liked elephant presence in the areas as long as HEC was kept under control. Three respondents (including one whose crop field had just been raided) said the presence of elephants was welcome as elephants brought rains (as is the locals' belief).

Mitigation Measures

The strategies adopted by the Forest Department to mitigate human-elephant conflict (HEC) in KWS were/are:

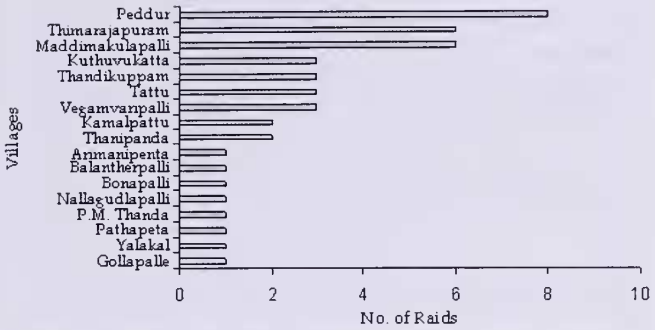

Fig. 4: Village-wise raids recorded during the study period

Electric fence: The Forest Department initially opted for electric fences, and between 1989 and 1992 laid a linear stretch of fence from the northern to southern end of the Sanctuary, positioned between the border of the Sanctuary and the reserve forests of Andhra Pradesh. This fencing was a failure since it was in the interior areas of the forest making maintenance and monitoring difficult, and also due to theft of fence material, including the supporting granite posts. Learning from this mistake, the Department started erecting fences in 1989 around enclosure villages and the edges of fringe villages. Till December 2005, about 100 km of fence had been erected with a balance of 60 km to be completed. Cooperation of villages was sought to ensure that the fence material was not stolen. The fences, except for the recently erected fence around the 'elephant camp', are solar-powered 4-strand fences supported by granite posts. Only the fencing around the elephant camp is the standard 7-strand fence with steel posts that is more widely used nowadays.

Removal of problematic animals: Removal of elephants (all bulls) by capture was necessitated when these animals took to manslaughter and/or became habitual crop-raiders. Some animals that dispersed out of the Sanctuary were also captured. A total of 6 bulls were captured in KWS and outside areas, and sent to zoos. One animal died during the capture operation.

Driving elephants from human habitation: The Forest Department has a team of 6 'elephant trackers' belonging to the tribal Yanadi community whose work is mainly to drive elephants off human habitation areas whenever reported with the help of crackers. Though never being familiar with elephants in the past, the team has gained experience over the years and is quite adept at this task without any loss to life or injuries till date.

Monetary compensation: Monetary compensation is an indirect method adopted by the Forest Department to mitigate HEC. Amounts are fixed (with revisions as felt necessary) for different HEC cases. The amount paid for manslaughter is currently Rs.1,00,000 up from Rs.10,000 during the 1980s. Assessment of crop damage is made by inspection of fields by the Forest Department along with officials of the Agricultural Department and the claimants. Locals interviewed said that adequate monetary compensation is a satisfactory solution for crop or property loss, but cannot compensate for the loss of human life. The problems cited regarding monetary compensation (a) Inadequate compensation (b) Time, procedures and resources needed to lodge complaints, and (c) Delays in getting compensation.

DISCUSSION

Human-elephant conflict in the KWS area was severe in the past, but has shown a marked decline in the past few years, especially with regard to manslaughter. There are a number of reasons for the decline in HEC. Two important factors are the fall in elephant population from about 80 to 12 individuals and the settling down of the current population (contra exploratory nature of the earlier herds and bulls). Another equally important contributory factor was the removal of problematic bulls. Most of the kills of humans in KWS were by tuskers, which is the trend in southern India where 80% of the manslaughter reported was by bulls though they constitute less than 10% of the total population (Sukumar 1991). Appaya (1992) reported that almost all the 56 problematic elephants that were translocated out of the isolated pockets of forests into larger forest tracts in Karnataka consisted of bulls. Sukumar (1991) reported that in less than a decade HEC has significantly reduced in the Chamarajanagar and Satyamangalam regions owing to poaching of bulls for tusks. Some bulls are inherently aggressive (especially during musth) and turn into habitual killers (Sukumar 1989; Cheeran 2002), and similarly, some of the captured bulls in KWS were reported to be wanton killers. One extremely large bull which was captured due to HEC problems, and which died soon after, is believed to have been responsible for many of the manslaughter cases in KWS. Another reason for decline in manslaughter is that the locals are now aware of the dangers of elephants, unlike earlier where whole villages would venture to see elephants that came near human habitation. Conversely now, herdsmen and woodcutter avoid venturing into forests areas on reports of elephant presence and quickly run away or take to the shelter of large trees on approach of elephants.

Bulls are also well-known to raid crops more frequently than family herds (Santiapillai and Ramono 1993; Appaya 1992; Daniel *et al.* 1995; Sukumar 1989, 1991). However, though the frequency of raids by males was more, the extent of damage caused by bulls and herds was not statistically different as the damage caused by a herd collectively is more than a bull's (Balasubramanian *et al.* 1995). Studies by

Baskaran and Desai (1996) revealed that only specific clans and males raid crops, which suggest that removal of crop-raiders can eradicate or mitigate crop damage. However, it has to be borne in mind that removal of bulls from the population would adversely impact breeding. At present, there are only two adult bulls (one which stays with the herd) in KWS, besides a subadult and juvenile bull, and it may just be a matter of time before they start to create problems. In fact, the elephant trackers anticipate this to happen in future especially in the case of the adult lone bull, which is becoming bolder.

Electric fences are regarded to be generally effective against elephants but constant maintenance is important to its success (Seidensticker 1984; Sukumar 1986, 1989, 1991; Balasubramanian *et al.* 1995; Daniel *et al.* 1995; Daim 1995; Santiapillai 1996). Fences backed by additional protection and stakeholders support (as in the case with privately owned plantations) were found to be more successful (Balasubramanian *et al.* 1995; Nath and Sukumar 1998; Chauhan and Chowdhury 2002). In non-privately owned fences, as is the case with KWS, people do not feel responsible for their maintenance even thought it benefits the village as a whole. However, it is difficult to stop elephants from raiding crops once agriculture becomes the principal land use in the vicinity of elephant reserves (Santiapillai and Ramono 1993) and since elephants learn to get through electric fences (Seidensticker 1984; Sukumar 1989; Santiapillai 1996) irrespective of design criteria (Thouless and Sakwa 1995; Nath and Sukumar 1998). In KWS, given the dynamic nature of the whole situation where elephant numbers have changed and problematic elephants captured (and killed by electrocution), it is difficult to attribute changes in crop raiding intensity to the electric fence. However, HEC data collected during this study shows that elephants raided crops even where fences exist by pushing down and breaking the exposed granite posts. The opinion gathered from villagers is that power fences do not really act as a barrier for crop raiders, but it does deter elephants from entering fenced areas if the animals are not intent on crop raiding.

As for KWS, while the single long fence failed, the current approach to fencing of one or more villages is more practical even though it has not stopped elephants from totally raiding crops. The causes of failures basically are (a) lack of stakeholder involvement where the villagers do not see the fence as their own and do not help in monitoring and maintenance (b) absence of participation by all stakeholders in the erection of fences resulting in breakage to enter forests for fuel wood, cattle grazing, etc., and (c) poor construction and use of unsuitable material, e.g., granite posts. As fences guarded at night are more secure than unguarded ones, some efforts must be made to guard fences, especially when elephants are reported near villages. Another important aspect that people and managers need to be aware and accept is that fences do not provide 100% solution and they only reduce the intensity of conflict. Hence, breakages by elephants should not be viewed as failures but rather looked upon as normal as long as the overall damage is reduced. However, given the poor quality of the existing habitat, the 'fencing off' of villages may result in elephants resorting to greater number of break-ins to get at crops in the event that natural food is not adequate, so habitat protection and improvement measures are an integral part of the HEC mitigation.

With regard to the drives from human habitation areas by elephant trackers, this strategy gives the false appearance of being successful mainly due to the small elephant population. The manpower requirements for this strategy would be huge and difficult to implement if the elephant population was larger with more herds and bulls operating in the area. The drives in fact only result in transferring the problem from one village to another or/and result in the animals coming back to the village after a gap of a few days. Elephants soon recognize such psychological bluffs and get accustomed to them (Santiapillai 1996). The drives are now taking longer with the animal retreating into the forests more leisurely. The elephant trackers in KWS report that the lone bull is now quite habituated to the drives and occasionally stands its ground and fling things at them during drives from crop fields. However, the presence of the trackers and drives gives a psychological boost to the affected villagers.

Considering all the above mentioned factors, it appears that a combination of decline in population, settling down of herds, removal of bulls and people's awareness are largely responsible for the decline in HEC rather than the effectiveness of the current HEC mitigation measures, i.e., power fences and driving by elephant trackers. A number of factors are responsible or act as catalysts for HEC in KWS as follows:

1. The small size of the Sanctuary, its linear shape and the extensive interface of forest and human habitation ensures that elephants encounter human use areas in every direction of movement.

2. HEC would be more severe when elephants start operating in a new area as they are unfamiliar with the area, resulting in constant encounter with people. People are also unfamiliar with elephants and are not geared to address HEC. Most fields have no crop protection and even when crop raiding starts, people do not know how to protect their crops from elephants unlike in areas where people are habituated to elephant depredations.

3. Elephants due to their large size and bulk food requirements are far-ranging mammals and radio-telemetry

studies show their home ranges to be as large as 500 sq. km for clans; 623 sq. km and 530 sq. km for cows, and 374 sq. km and 210 sq. km for bulls (Baskaran *et al.* 1995; Daniel *et al.* 1995), and thus are more likely to come into contact with human habitation and take to crop-raiding than other mammals, and especially as elephant habitats shrink and/or get degraded (Sukumar 1986, 1989; Daniel *et al.* 1995; Nair 2004).

4. The general scarcity of water in forest areas in summer (especially during low rainfall years) and its availability in irrigation tanks near human settlements act as catalysts for crop-raiding. Many of the check-dams constructed to supplement water resources for elephants are at the edges of the forest instead of interior areas. These water sources attract elephants, and in such situations, crop-raiding occurs as a consequence of the need for water, which for elephants is significant at around 200-250 litres/day (Sukumar 1989; Cheeran 2004). Water sources acting as catalysts for crop raiding have been reported by other workers (Seidensticker 1984; Sukumar 1989, 1990; Ramesh Kumar 1994; Daniel *et al.* 1995).

5. Habitat loss or degradation through grazing by livestock and wood-cutting by locals, and also the decline of food plants due to over-utilization by elephants due to 'pocketing effect' (especially applicable to small sanctuaries) and loss of corridors to adjoining forest tracts also results in crop-raiding. In such situations, feeding habits soon become environment destroying activities as migratory routes are blocked and forage supply diminishes (Wing and Buss 1970). Villages and crop fields bordering such forests will face more HEC due to the suboptimal resources (Sukumar 1986; Daniel *et al.* 1995). It is estimated that prime elephant ranges have shrunk by 20-25% in southern India within a century and fragmentation has brought elephants closer and in conflict with people (Sukumar 1989, 1990).

6. Even if the above mentioned problems do not exist, elephants will continue to raid crops since cultivated species are highly nutritious, more palatable and less toxic than their wild counterparts and require less feeding effort due to single species dominance (Sukumar 1985, 1989, 1990). Though not much highlighted in studies, crop-raiding in grass deficient areas like KWS could be more related to requirements of grass in the diet than other factors considering that Poaceae (Graminae) species such as finger millet are preferred during crop-raids.

CONCLUSION

Other than the requirements of extensive landscapes for survival, conservation initiatives become more difficult for elephants due to the problem of HEC. The Indian Government annually spends about Rs. 100-150 million on measures to control crop depredation and ex-gratia payment to the victims of depredation. HEC not only breeds hostility among the locals towards elephants but also towards Forest Department staff (Bist 2002). In the case of KWS, most of the locals living at the borders of the Sanctuary are poor and cannot be expected to live with elephants in their vicinity (which were not there earlier), suffering ensuing economic losses and tolerating the inconveniences and threats to lives and livelihoods.

As discussed in detail earlier, preventing crop raiding in KWS is extremely difficult due to the small size of the Sanctuary, its linear shape with an extensive interface of forest and human habitation areas, scarcity of water in summer and compounded by its availability around village surroundings, habitat loss and degradation through human related factors and 'non-sustainable use' of food plants by elephants due to their 'pocketing' in KWS with the loss of corridors and adjoining forests. Due to these factors and since the long-term survival of the small population of elephants in KWS is bleak, the practical solution to tackle HEC would be the removal (translocation or capture for zoological parks) of elephants from the Sanctuary, as has been suggested by others for sites facing pressures and having small populations (McKay 1973; Sukumar 1986,1989; Santiapillai 1996). However, if the Andhra Pradesh Forest Department is keen on the conservation of the elephants, which are the *raison d'etre* of the Sanctuary, then besides attending to some of the lacuna in HEC mitigation discussed earlier, the following are recommended:

Protection of habitat: Protection of habitat would be the key factor in improving the status of elephants in KWS. If it is difficult to stop fuel wood collection, cutting of small timber, fires and cattle grazing, then it will be impossible to improve the situation for the existing population, let alone a much larger one needed for long-term conservation.

Collaboration with the Tamil Nadu Forest Department to protect border areas: The eastern and south-eastern borders of the Sanctuary are contiguous with the reserve forests of Tamil Nadu. These reserve forests face major threats for fuel wood from the people of the plains and these pressures are progressing into the Sanctuary areas. Hence, the officials of the Sanctuary need to collaborate with the Tamil Nadu Forest Department to put a check on the pressures and disturbances in these areas.

Inclusion of reserve forests into the Sanctuary: As the Sanctuary is small and narrow, and due to its insularity, the adjoining reserve forests of Andhra Pradesh on its western border should ideally be incorporated into the Sanctuary to enjoy the enhanced benefits that sanctuaries have compared

to reserve forests. Many of the reserved forest areas are already being used by elephants as there are no barriers to stop them from entering these areas. However, the inclusion would have an impact only if the change in status of the land results in greater protection and improvement of habitat in a manner suitable for elephants.

Habitat Enrichment: A number of habitat enrichment plots of food plants for elephants have already been established by the Forest Department. Most of them are at the outskirts of villages, and hence, are either avoided by elephants or act as catalysts for human-elephant conflict. As browse availability appears to be sufficient and it is grass availability that is scarce in the Sanctuary, planting of browse species is unnecessary and instead grass or bamboo plots could be established. Areas having alluvial soils or moist conditions should be preferred as these give rise to more palatable grass species. However, grass availability is best addressed through reduction/stopping of cattle grazing as there would be little use in trying to grow grass if cattle grazing persists. Additionally, habitat enrichment would be futile if the other factors responsible for habitat degradation cannot be addressed.

Creation of water sources inside the Sanctuary: One reason for human-elephant conflict in KWS is due to the scarcity of water during summer compounded by its availability near human habitation. For this reason, we suggest construction of a few more water resources in the interior forest areas and development and protection of important water sources. Posting of Forest Department watchers at some of the important sites during summer is recommended as poachers of other wildlife tend to camp around waterholes during summer. Construction of water resources is generally discouraged since it causes artificial increase in elephant pressures on vegetation around waterholes, especially during the dry season (Daniel *et al.* 1995; Santiapillai *et al.* 1995; Sukumar 1989), but is essential in Koundinya as water resources tend to be scarce during low rainfall years causing elephants much hardship and encouraging HEC. These negative impacts of waterholes could be lessened if they are well distributed (see Seidensticker 1984). Additionally, artificial supply of water has been found to give rise to relatively small and stable elephant home ranges (Whyte 2001), which could prevent wandering of the KWS elephants into border areas and thus reduce human-elephant conflict.

Planting of alternative crops: The Forest Department, in consultation with the Agriculture Department, could encourage the villagers to grow crop species that are not palatable or less preferred to elephants such as chillies, lemon and mulberry. Providing incentives/subsidies/loans to the villagers and facilities like drip irrigation, help in transport of goods and finding buyers for the produce will be required to achieve this objective as villagers tend not to change unless help and facilities are offered.

Monetary Compensation for HEC: There is a need to have simple and clear procedures for registering, evaluation and payment of claims, so that people become aware of these and transparency is established. As most of the affected are illiterate and subsistence farmers, and tend to be wary of officialdom, payment of compensation claims in the field in the presence of village officials would be a helpful solution.

Eco-development: With the pressures facing the Sanctuary for its natural resources from bordering villages, it appears unlikely that the Sanctuary can survive into the future unless it receives the support of local communities. For this, the conditions of the local villagers need to be improved and their dependence on forest resources reduced or stopped by providing alternatives. There are already two schemes in KWS working towards this objective, the Vana Samrakshna Samithi (VSS) and the Eco-Development Committee (EDC) both funded by the World Bank and coordinated by the Forest Department. The focus of these schemes are to uplift the standard of life of the villagers by providing support in improvement in agriculture, animal husbandry and setting-up small scale or cottage industries; providing employment through soil and moisture conservation works and construction of checkdams; introduction of alternative fuel (biogas) and fuel saving devices (*choolas*); harvest and processing of minor forest produce on a sustainable basis; and augmentation of fuel wood and fodder in community lands. However, judging from the pressures and disturbance recorded in the forest during the study, it appears that these schemes have still not achieved their objectives as far as people's dependence or exploitation of forest resources is concerned. As increase in human population will put more pressures on the success of these schemes, family planning should be included as an important component of these programmes. Eco-development is especially vital for small sanctuaries with villages at their fringes and a growing population (as in the case of KWS), and it is important that schemes like the VSS and EDC are successful if the Sanctuary is to survive into the future.

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